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EFFECTS OF GLASS AND CARBON FIBER HYBRIDIZATION ON MECHANICAL PROPERTIES OF JUTE FIBER REINFORCED POLYPROPYLENE COMPOSITES

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ABSTRACT

Experiments were conducted on jute fiber reinforced polypropylene (PP) composites to optimize the content of fiber in the composite. It was found to be 40wt%. In the present study, effects of hybridizing glass fibers and carbon in the optimized jute fiber reinforced PP composite have been studied. The properties such as tensile, flexural and impact with respect to randomly oriented jute, glass and carbon fiber variations in the PP matrix are considered. Jute, glass and carbon fibers reinforced PP matrix composites with different fiber contents were prepared by injection molding. Matrix content is kept as 60wt%. The hybridization of the fibers considered by weight fraction for jute and glass is 20:20, for jute and carbon is 20:20 and jute, glass and carbon is 20:10:10. Results showed that tensile, flexural and impact properties have been improved with glass fiber hybridization and further improvement in these properties are observed with carbon fiber hybridization. When glass and carbon fibers are added in 10:10 weight percentage the considered mechanical properties have been found to be nearer to the composite with 20 wt% of carbon.

Key words: Jute fiber, Glass fiber, Carbon fiber, Polypropylene, Tensile, Flexural, impact

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1. INTRODUCTION

Presently, fiber reinforced composites are in use in variety of applications like, automotive interiors and body parts, furniture, aircraft panels etc. This wide use of composites has been facilitated by the introduction of new materials, improvement in manufacturing processes and testing methods. Fiber-reinforced materials have better mechanical properties, and their strength-to-weight ratios are superior in comparison with those of most alloys. When compared to metals they offer many other advantages like, non-corrosiveness, translucency, good bonding properties, and ease of repair. Natural fibers offer many attractive technical and environmental qualities when used as reinforcements in polymer composites [1, 2, 3, 4, 5]. Synthetic fiber composites have better mechanical properties [6, 7] when compared with those of natural fiber composites [8, 9, 10, 11]. However, recycling of synthetic fibers is difficult. Use of natural fibers as reinforcements has been limited due to their lower strength, stiffness and toughness compared with those of synthetic fiber reinforced polymer composites [12-14]. Strength, stiffness, and toughness shortcomings of natural fiber reinforced composites can be overcome by hybridizing natural fiber reinforced composites with synthetic fibers [15, 16, 17, 18, 19]. To take advantage of both natural and synthetic fibers, they could be combined in the same matrix to produce hybrid composites that take full advantage of the best properties of these constituents. Hence hybridization of synthetic fibers such as glass and carbon with jute fiber reinforced PP composite is considered in this research work.

2. MATERIALS AND METHODS

2.1. Materials

Thermoplastic polymer PP, used as matrix material is in the form of homopolymer pellets supplied by Hindustan polymers, Bangalore, India. It has specific gravity of 0.90–0.91, melting temperatures of 165–171^{0}C and crystallinity of 82%. White jute fiber (Corchorus capsularis) used as reinforcing fiber was obtained from Jute Pragna Suppliers, Bangalore, India. An E-Glass fiber used as reinforcing fibers was obtained from Concord Fiber Glass industries, Bangalore, India and carbon fibers is obtained from Techno Engineering Products, Bangalore, India.

2.2. Fabrication of composites and test specimens

Jute, glass and carbon fibers in the weight percent ratios of 40:00:00, 40:20:00, 40:00:20, and 40:10:10, were initially mixed thoroughly with PP granules (60wt %). The mixtures were passed through single screw extruder at a constant temperature of 170^{0}C. The extruded composites were cut into pellets using rotary cutting pellet making machine. The test specimens were prepared from the compounded pellets using injection molding machine as per ASTM standards.

2.3. Mechanical testing

Tensile, Flexural and Izod impact tests were conducted. For each test and type of composite, 4 specimens were used and the average values are presented.

2.3.1. Tensile test

Tensile tests were conducted according to ASTM D 638 using a Universal Testing Machine (Make: Hounsfield, UK, Model: H 50 KM, Capacity: 50 KN, Jaw separation speed: 1 to 500

mm/min). The dimension of the dog bone shaped specimen was 175 mm x10 mm x 3.2 mm. Gauge length was 50 mm.

2.3.2. Flexural test

Three-point static flexural tests were carried out according to ASTM D 790 using the same testing machine mentioned above. The dimension of the specimens used was 125 mm x12.5 mm x 3.2 mm. Span length was 100 mm.

The flexural strength and modulus were calculated using the equations 1 and 2 respectively

$$\text{Flexural strength} = 3PL/2bd^2 \quad (1)$$

$$\text{Flexural modulus; } E = L^3m/4bd^3 \quad (2)$$

Where P is the maximum applied load, L is the length of support span, m is the slope of the tangent, b and d are the width and thickness of the specimen respectively.

2.3.3. Izod impact test

Izod impact tests were conducted on un-notched composite specimens according to ASTM D256, using pendulum impact tester (Range: 0 to 1.5 Joules). The dimension of the specimen was 65 mm x 12.5 mm x 3.2mm.

3. RESULTS AND DISCUSSION

3.1. Tensile properties

Variation in tensile strength with respect to Jute, glass and carbon fibers reinforcement in the weight percent ratios of 40:00:00, 40:20:00, 40:00:20 and 40:10:10 is shown in Figure 1. It could be seen that, tensile strength is increased by 28.67% with glass fiber hybridization by 20 wt%. This is due to the better adherence of glass fibers to the matrix in comparison to jute fibers with PP. Better the adherence, higher is the load required to pull the fiber from the matrix Increase in tensile strength is 42.2% when carbon fiber is hybridized with jute fiber reinforced composite. Since the carbon fibers have better inherent mechanical properties than glass fibers and also the better adherence to the matrix because of its surface texture its addition has resulted in higher tensile strength. When the hybridization of glass and carbon fibers is 10 wt% each the increase in tensile strength is 38.86%, which is almost nearer to the carbon fibers hybridization with 20 wt%.

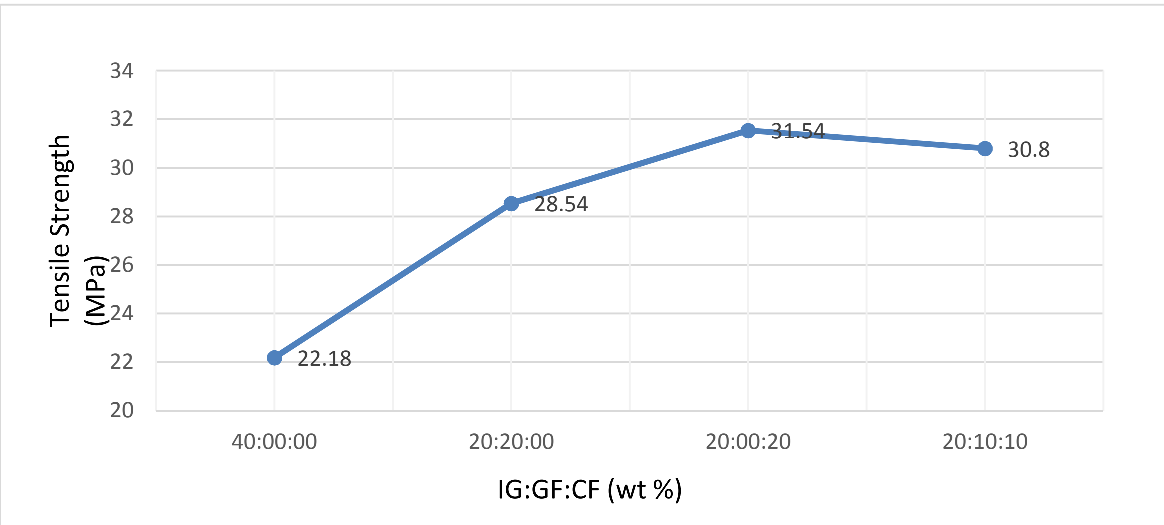

Figure 1. Variation of the tensile Strength at different glass and carbon fiber hybridization

Figure 2 shows the variation of the tensile modulus at different glass and carbon fiber loading. Tensile modulus is increased with glass fiber hybridization by 25.77% and carbon fiber addition by 51.07%. With glass and carbon fibers addition to the jute fiber reinforced composite by 10 wt% each the increase in tensile modulous is 42.69%. This is attributed to the higher modulus of glass fiber and still higher modulus of carbon fibers than the jute fiber and PP matrix. Normally, the fibers in the composite restrain the deformation of the polymer matrix, reducing the tensile strain. During tensile loading, partially separated micro spaces are created, which obstruct stress propagation between the fibers and matrix. As the glass and carbon fibers are added to the composites, the degree of obstruction increases, which consequently increases the stiffness.

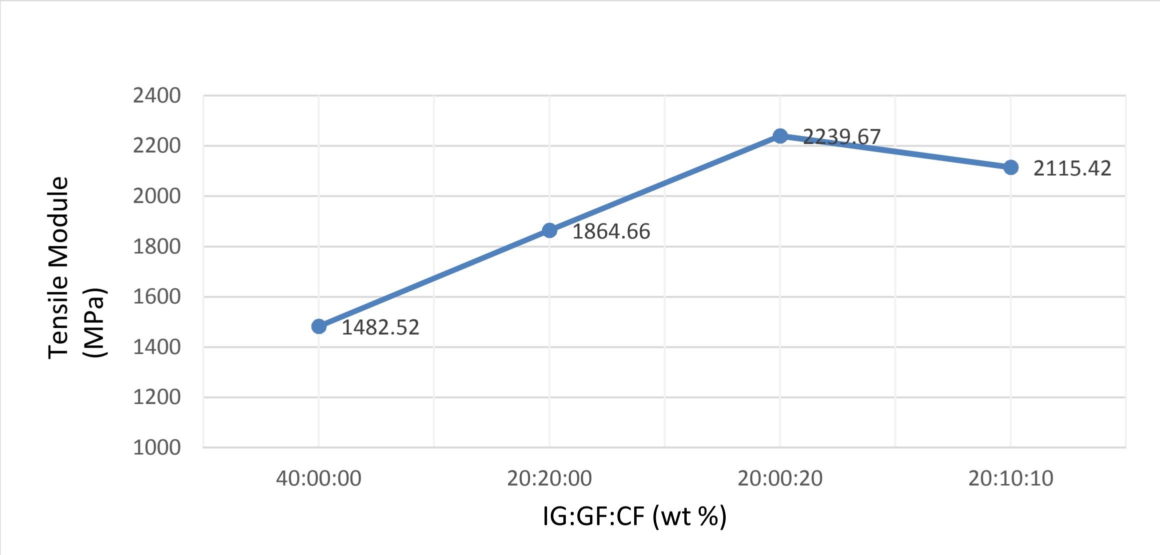

Figure 2. Variation of the tensile modulus at different glass and carbon fiber hybridization

3.2. Flexural properties

Flexural strength of hybrid composites with Jute, glass and carbon fibers reinforcement in the weight percent ratios of 40:00:00, 40:20:00, 40:00:20 and 40:10:10 is shown in Figure 3. It increased with 20 wt% of glass fiber addition by 20.82%. This is due to the fact that some of the glass fibers are fractured, some are pulled out of matrix and some adhere to the matrix. The glass fibers in the portions of the matrix get aligned in the direction perpendicular to the application of the load. These reasons justify the increase in flexural load bearing capacity of the material. When carbon fibers are reinforced with jute fiber reinforced composites the increase in flexural strength is 27.78%. This is due to higher strength of carbon fibers and better adherence to the matrix which calls for higher load to be pulled out of the matrix and also to fracture the fibers. When the hybridization of glass and carbon fibers is 10 wt% each the increase in flexural strength is 25.36. This value is closer to carbon fibers hybridization with 20 wt%.

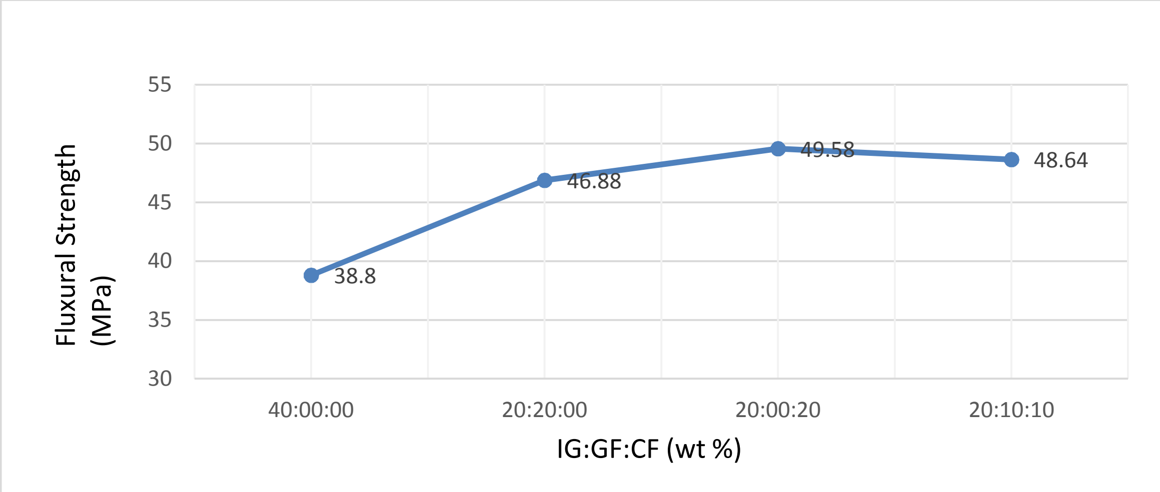

Figure 3 variation of the flexural strength at different glass and carbon fiber hybridization

Variation in flexural modulus of jute glass and carbon fiber hybrid composites at different fiber loading is shown in Figure 4.

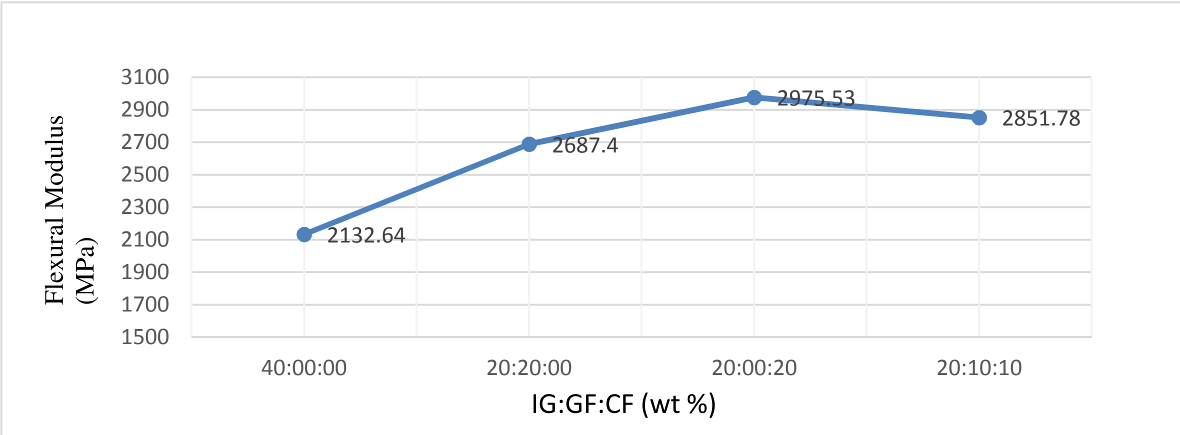

Figure 4 Variation of the flexural modulus at different glass and carbon fiber hybridization

3.3. Impact properties

Variation in Izod impact strength of Jute, glass and carbon fibers reinforcement in the weight percent ratios of 40:00:00, 40:20:00, 40:00:20 and 40:10:10 is shown in Figure 5.

Impact strength of the fiber reinforced composites depends on the nature of the fiber, polymer and fiber–matrix interfacial bonding. It could be seen that the impact strength is increased with glass fiber hybridization by 62.97% and cabon fiber hybridization by 111.7%. Impact strength in fiber reinforced composites is caused by fiber fracture and fibers pull out. More energy is required to fracture the composite than it is required for fiber pull out. Since the failure of the specimen is mainly by fiber fracture and due to good interfacial adhesion between glass fiber and the matrix, and still better interfacial adhesion between carbon fibers and matrix strength is increased with increase in glass fiber content and further improvement is observed with carbon fiber hybridization. With glass and carbon fibers hybridization to the jute fiber reinforced composite by 10 wt% each, increase in impact is 116.75. This increase in impact strength is higher than the composites hybridized with glass and carbon fibers separately, showing that there is synergetic effect of the hybridization of glass and carbon fibers together.

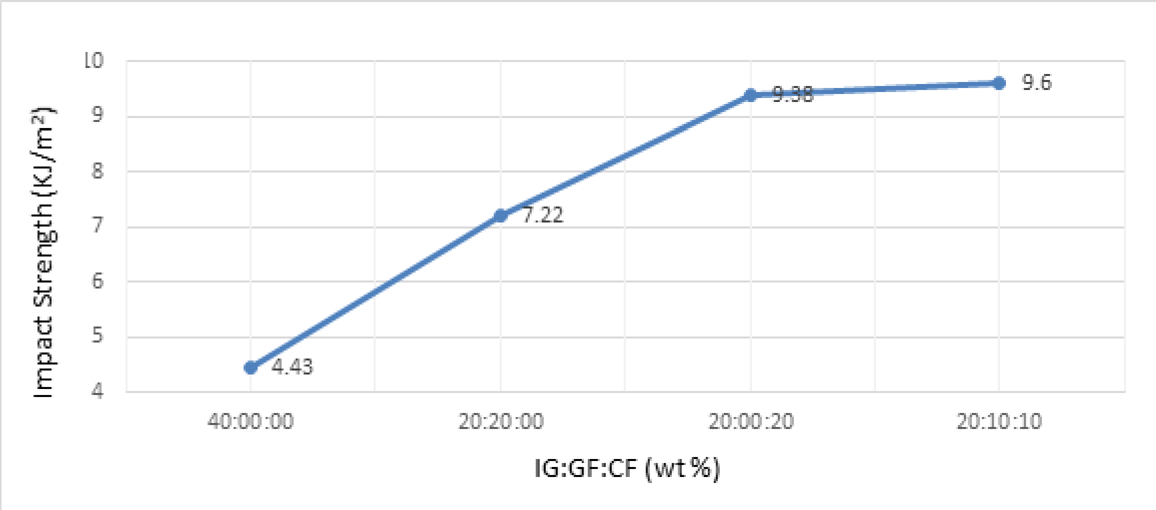

Figure 5 Variation of the impact strength at different glass and carbon fiber hybridization

4. CONCLUSIONS

The mechanical properties such as tensile, flexural and Impact of the glass and carbon fibers hybridized with jute fiber reinforced composites were studied by different weight ratios of jute, glass and carbon fibers. Tensile strength, tensile modulus, flexural strength, flexural modulus and impact strength of the composite were found to be increased with addition of glass fiber and further enhancement in these properties have been observed with the carbon fiber hybridization. When both glass and carbon fibers are reinforced in the composites, the tensile and flexural properties are higher than that of only glass fiber hybridization and comparable to that of only carbon fiber hybridization. The impact strength of glass and carbon fibers hybridized composite has shown synergetic effect with the value higher than that of carbon fiber hybridization. This higher impact property of the developed hybrid composite could make it suitable for applications like dash boards, frontal and rear bumpers of automobiles.

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